Using microwave limb sounder data to validate model ice fields

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ECMWF

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GSFC/NASA

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CSU

MLS Estimates & Model Values

- **MLS : August 2004 - July 2005**

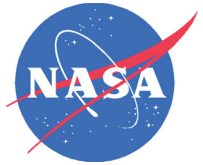
- **ECMWF analyses**
  - at 0, 06, 12 & 18 Z; August 2004 ~ July 2005
  - from the Integrated Forecasting System (IFS) *= Model + Observations*

- **ECMWF forecasts *= Model Only***
  - at 12, 24, 48, 120 and 240 hours; August 2004 ~ July 2005

- **Multi-year AMIP-like mean** from GCMs using Multiscale-Modeling Framework (MMF, i.e. "super-parameterization").

  - **CSUMMF - AMIP year run 1986 ~ 2000**
  - **GSFC fvMMF – Year 1998 and 1999**

JPL
WCC

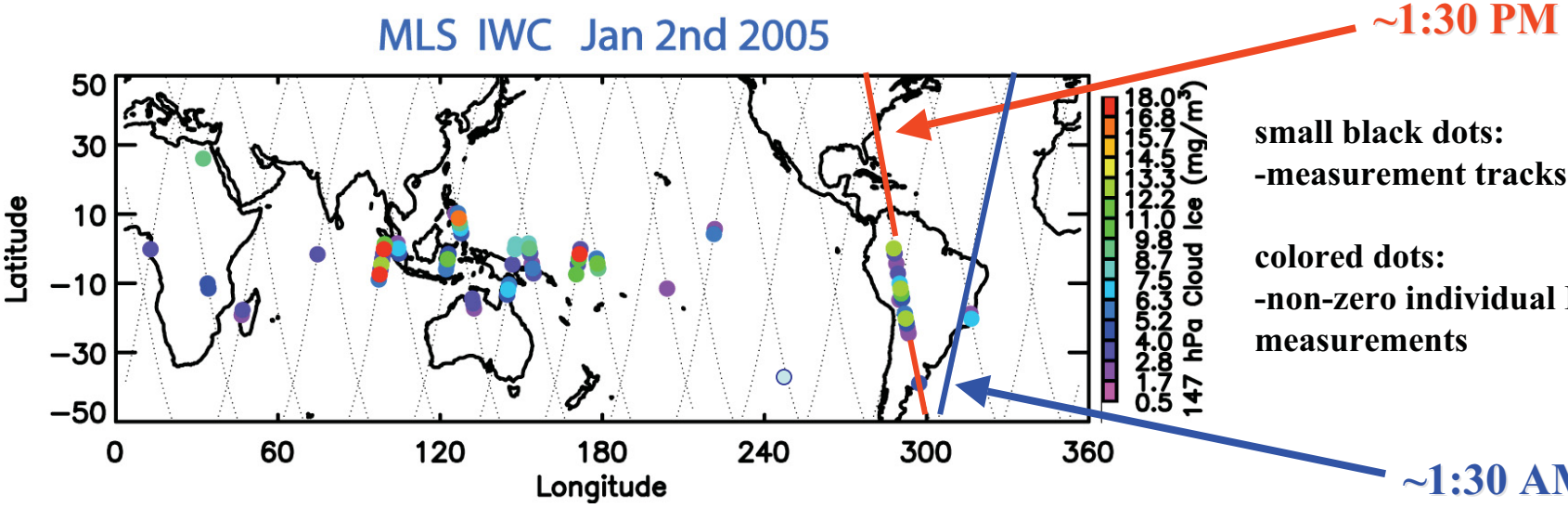


ECMWF ANALYSES

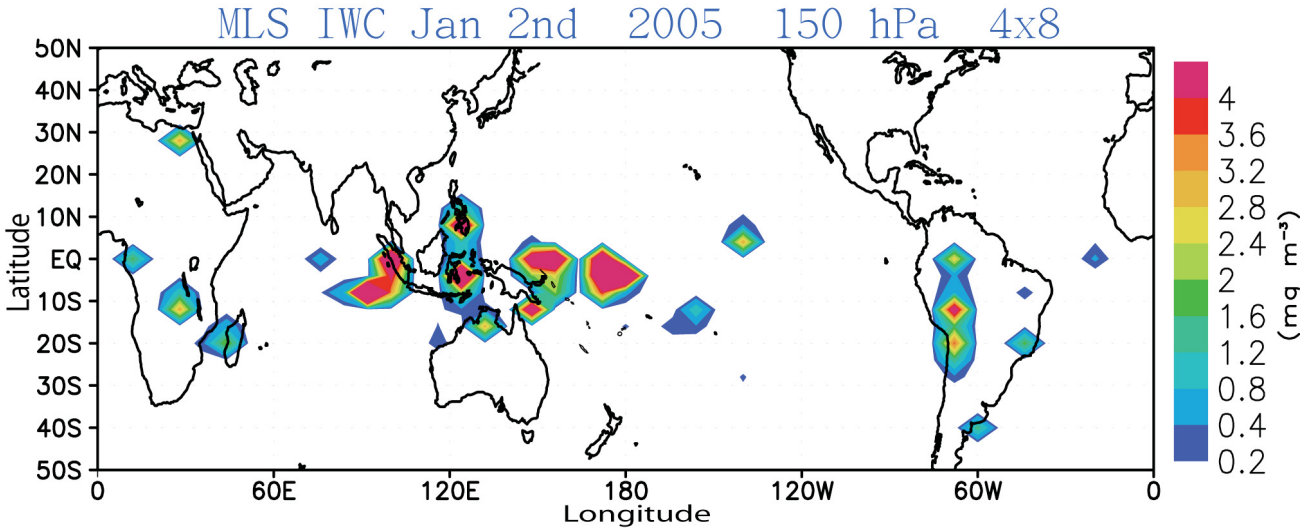
Model values but strongly constrained by observations.

MLS IWC for January 2nd 2005

147 hPa



IWC amounts divided by the total number of measurements (including cloud free conditions) at each 4°× 8° lat-lon MLS grid.



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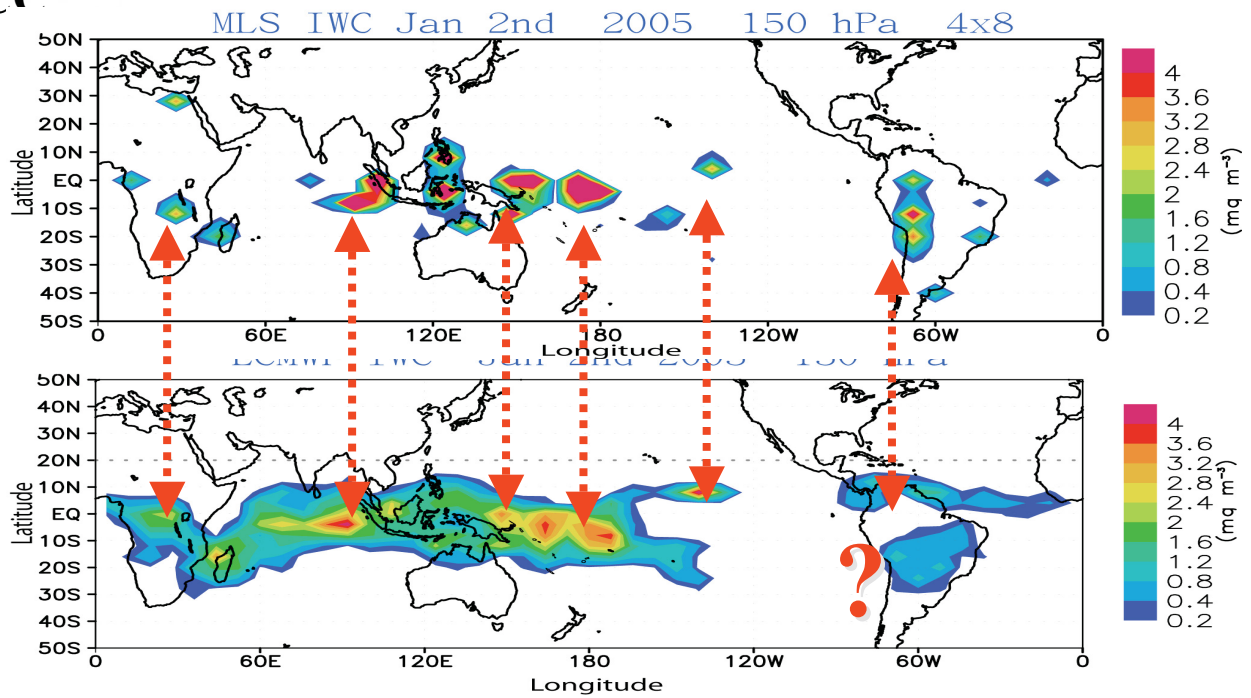
MLS vs ECMWF: January 2nd 2005

147 hPa



MLS
Twice daily

ECMWF
00,06,12 and 18z

SAMPLING ISSUES TO CONSIDER:

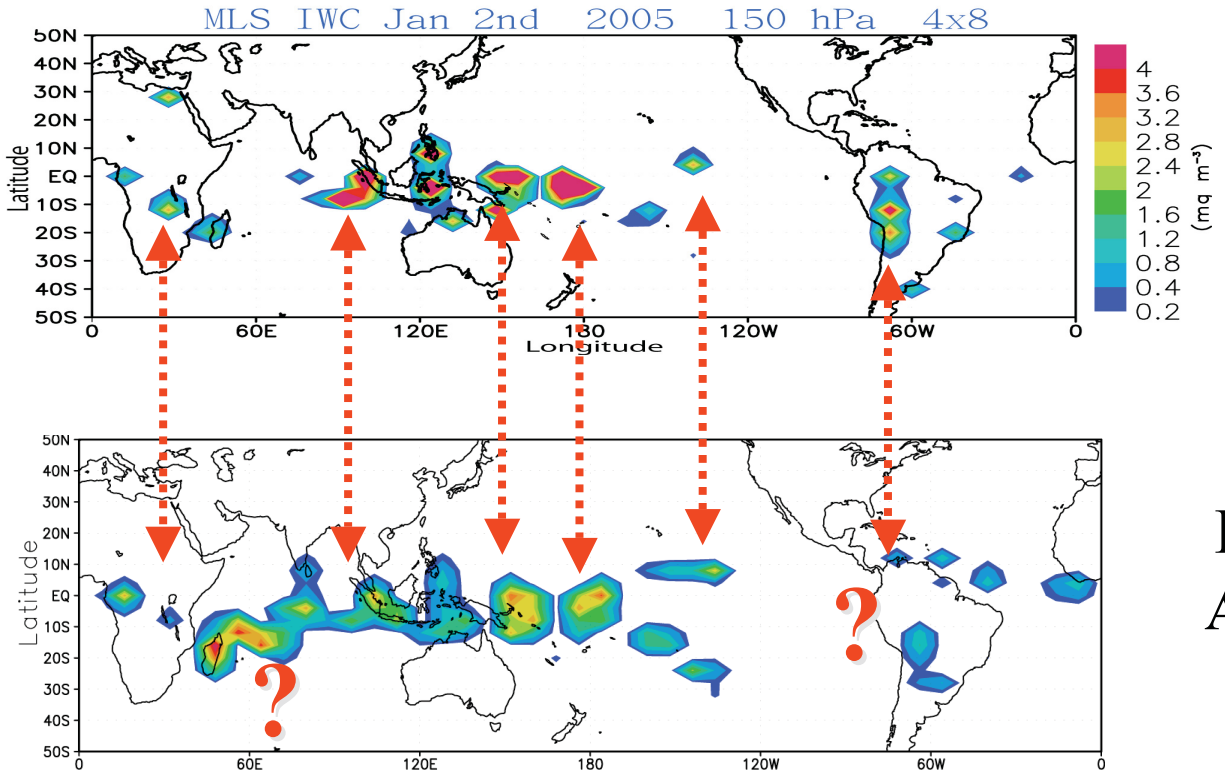
- MLS 2xDaily Local Times : ECMWF 4xDaily GMT Times
  - Diurnal Variability
  - MLS FOV vs ECMWF gridbox averages
- MLS Sensitivity (i.e. medium to large IWC)

MLS UNCERTAINTIES & VALIDATION:

- Instrument + Algorithm Uncertainty
- Systematic Bias: Formal validation has yet to be complete

MLS vs ECMWF: January 2nd 2005

147 hPa



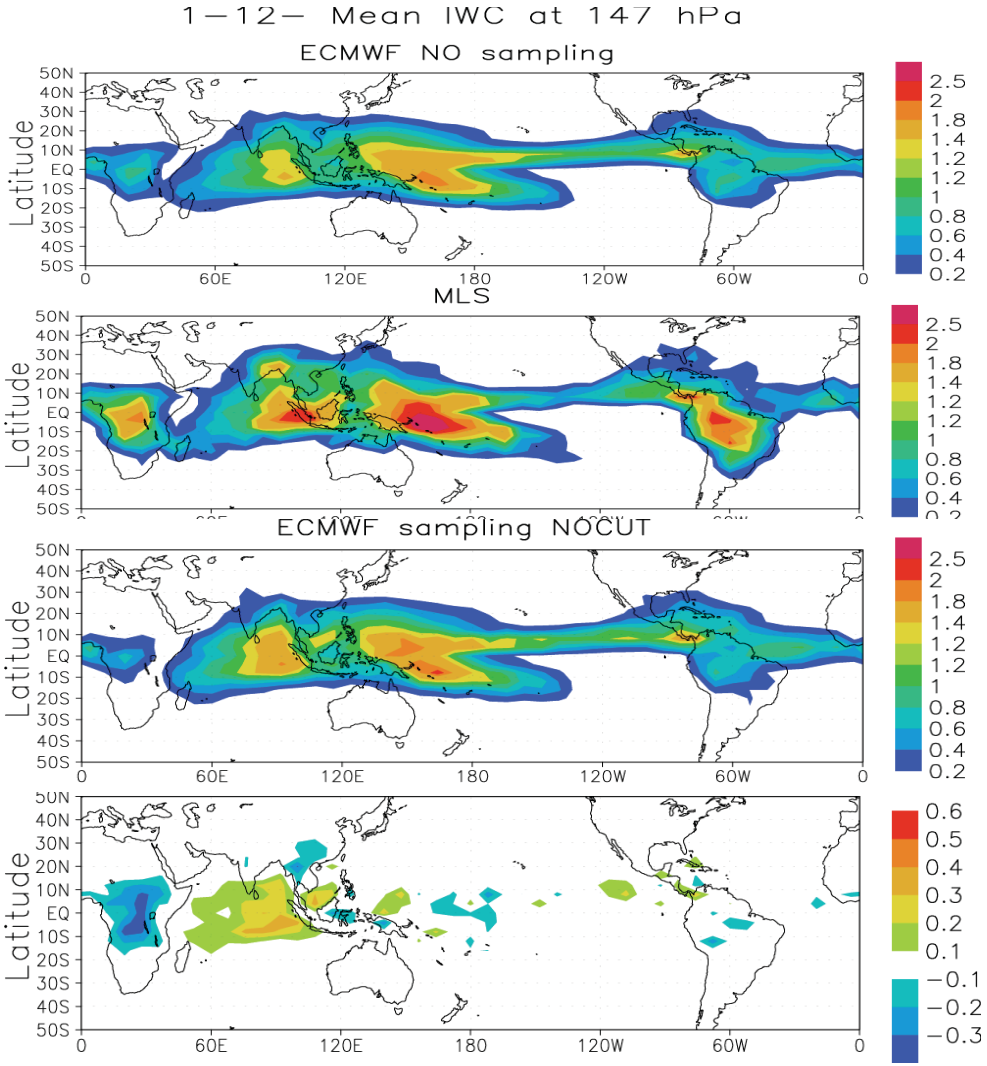
MLS
Twice Daily

ECMWF Sampled
Along MLS Tracks

- **Better agreement in spatial variability**
- **Sampled ECMWF IWC ~1-2 times smaller than MLS data**
- **Disagreement over Indian ocean and S. America**
  - sampling of diurnal cycle?

Annual Mean IWC @147 hPa

ECMWF Sampled Along MLS Tracks



ECMWF

MLS : Twice-Daily

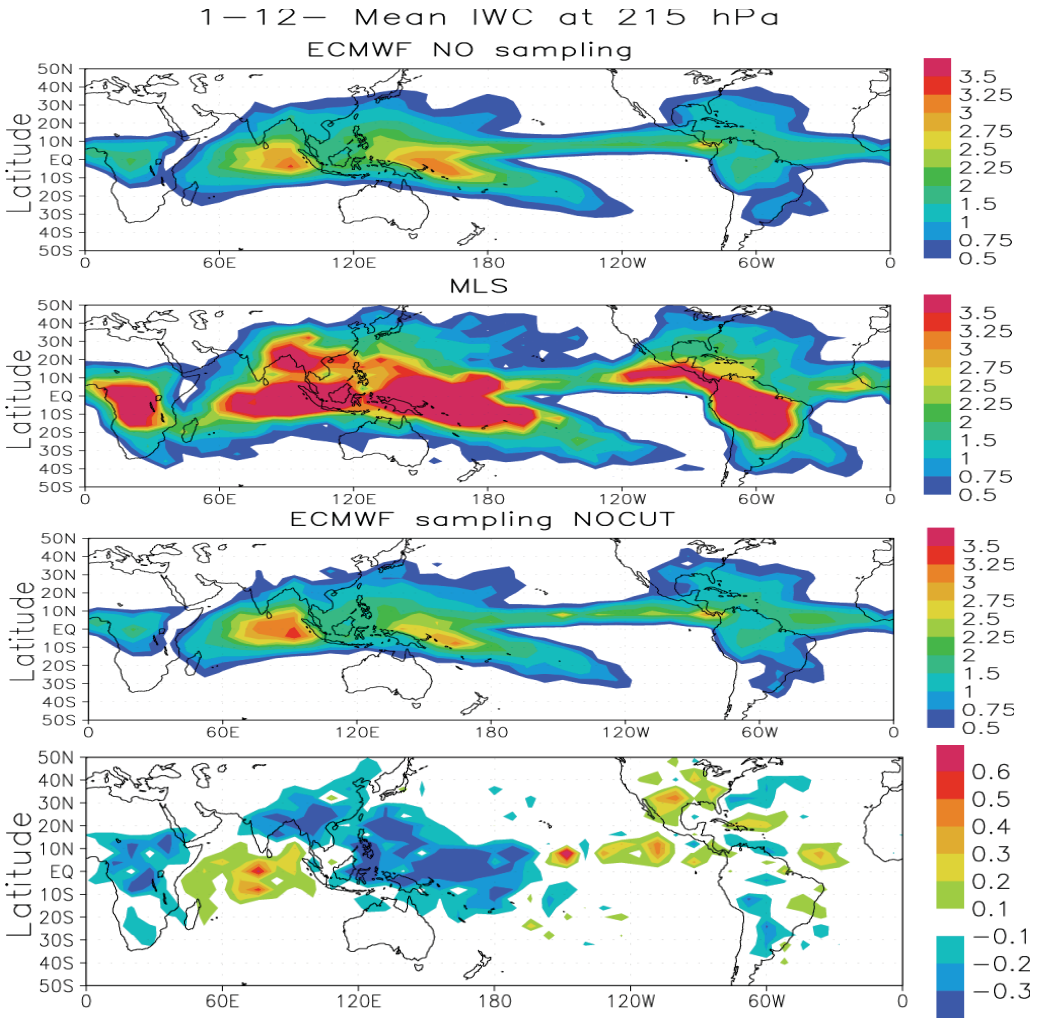
ECMWF : Sampled along MLS tracks

ECMWF Sampled - ECMWF

Results indicate track-sampling/diurnal effects have some impact on comparisons

Annual Mean IWC @215 hPa

ECMWF Sampled Along MLS Tracks



ECMWF

MLS : Twice-Daily

ECMWF : Sampled along MLS track

ECMWF Sampled - ECMWF

Results indicate track-sampling/diurnal effects have some impact on comparisons

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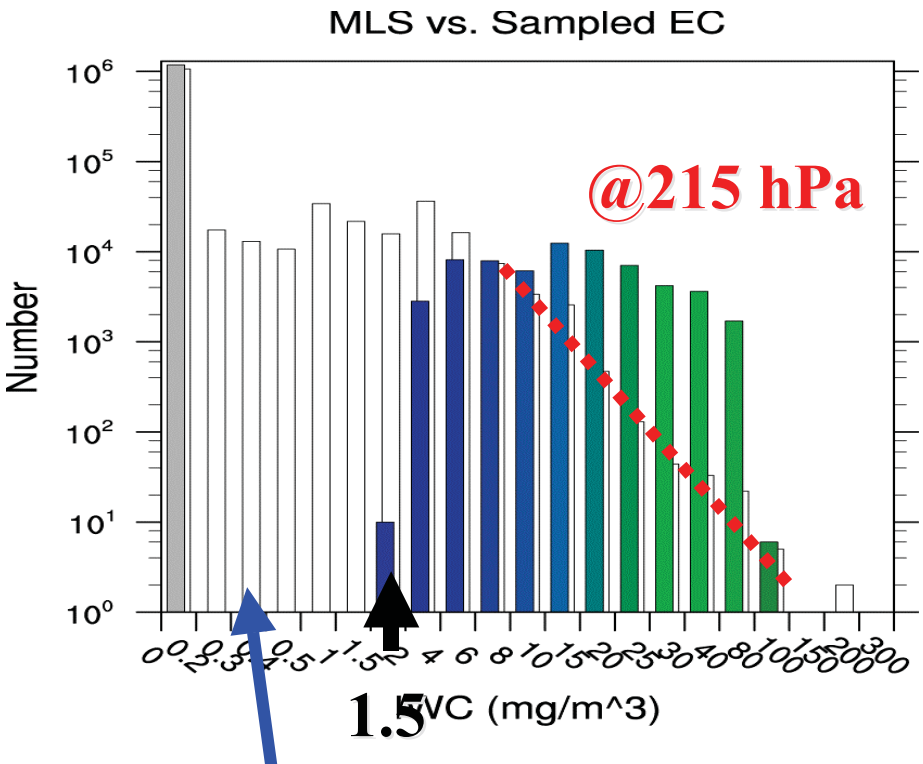
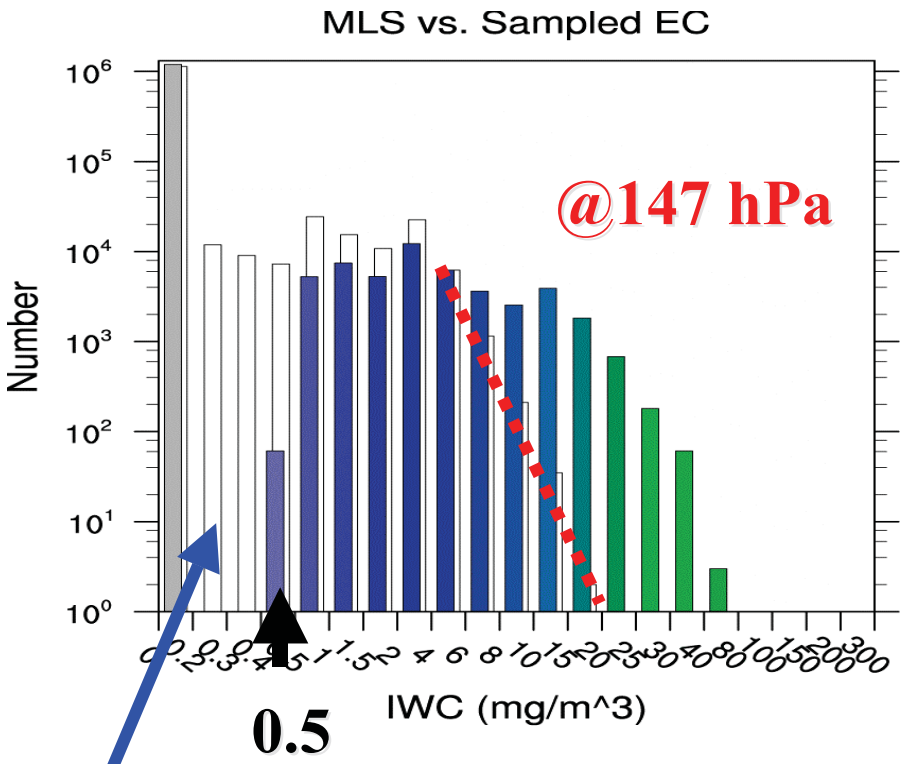
Annual IWC PDF: ECMWF vs. MLS

ECMWF Sampled along MLS tracks

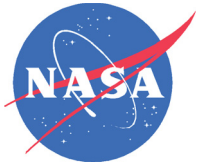
Color: MLS





ECMWF has less high IWC values than MLS data

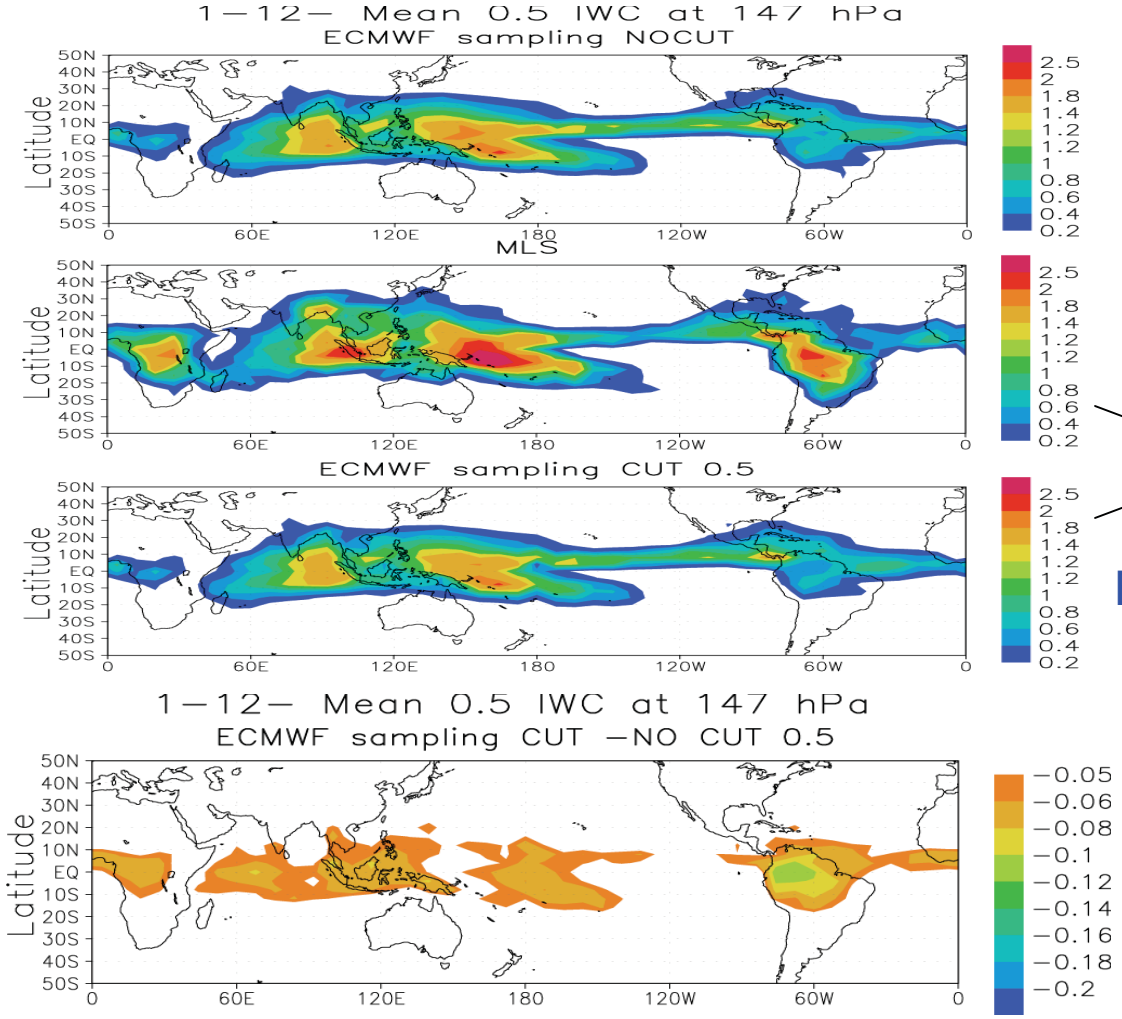
MLS is not sensitive to smaller IWC.



To make ECMWF and MLS sampling more consistent, consider MLS IWC sensitivity and apply cutoff values of 0.5 @ 147 hPa and 1.5 @ 215 hPa to the 4xdaily ECMWF IWC values that have been sampled along MLS tracks. -> Examine impacts on spatial distributions.

Annual Mean IWC @147 hPa

Considering MLS Sensitivity on ECMWF Values



ECMWF : Sampled, no cutoff

MLS : Twice-Daily

Best case comparison

ECMWF : Sampled, 0.5 cutoff

(changes small values to 0's and lowers mean values)

ECMWF sampled, cutoff - ECMWF sampled, no cutoff

ECMWF sampled with cutoff is factor of 2~3 smaller than MLS.

Similar results are found for other levels and seasons.

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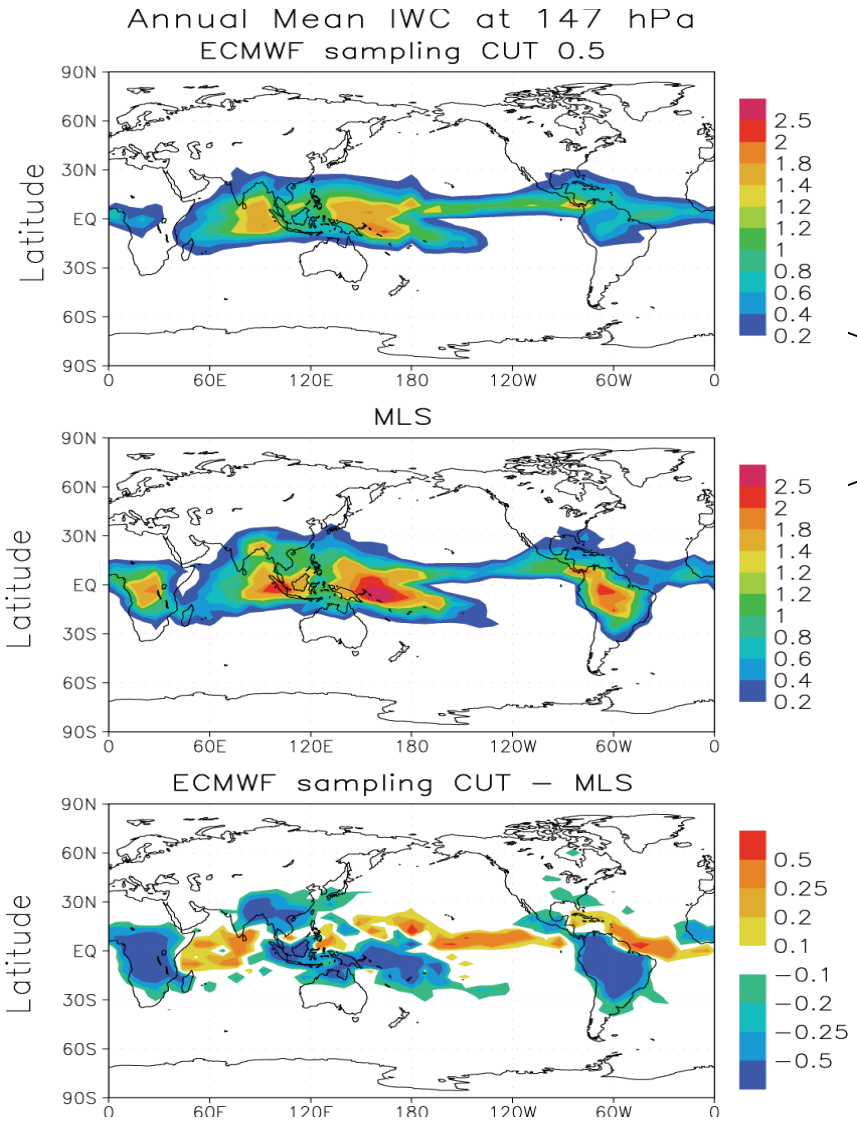
Annual Mean IWC @147 hPa

Considering MLS Sensitivity on ECMWF Values

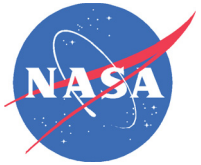


ECMWF : Sampled, 0.5 cutoff

Best case comparison

MLS : Twice-Daily

ECMWF - MLS



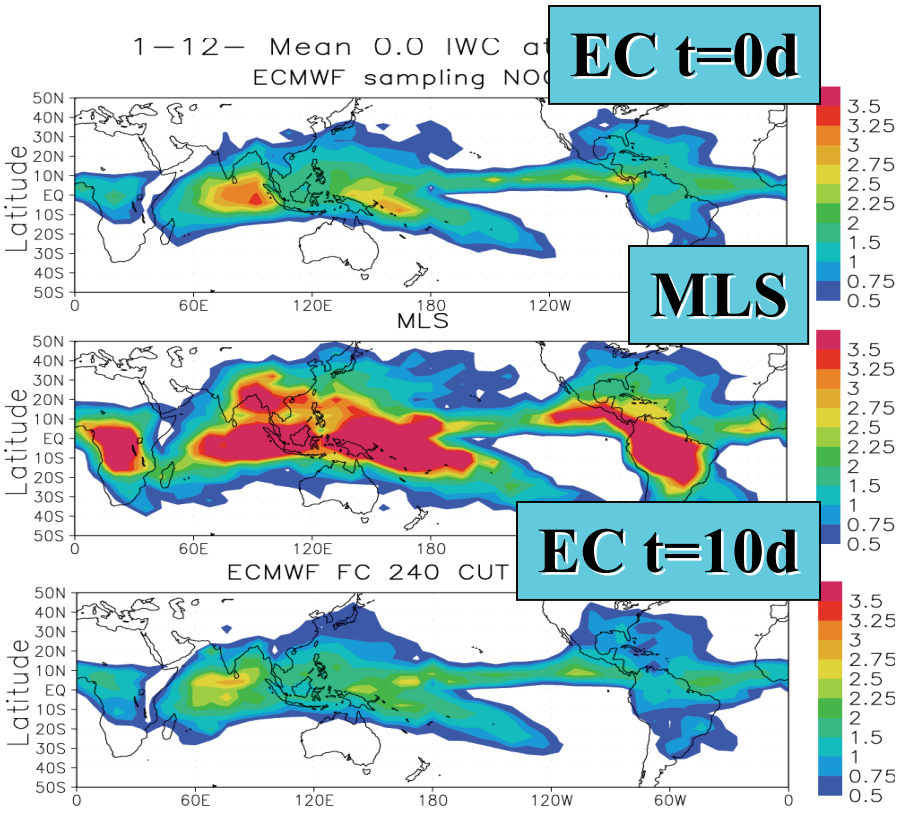
ECMWF FORECAST

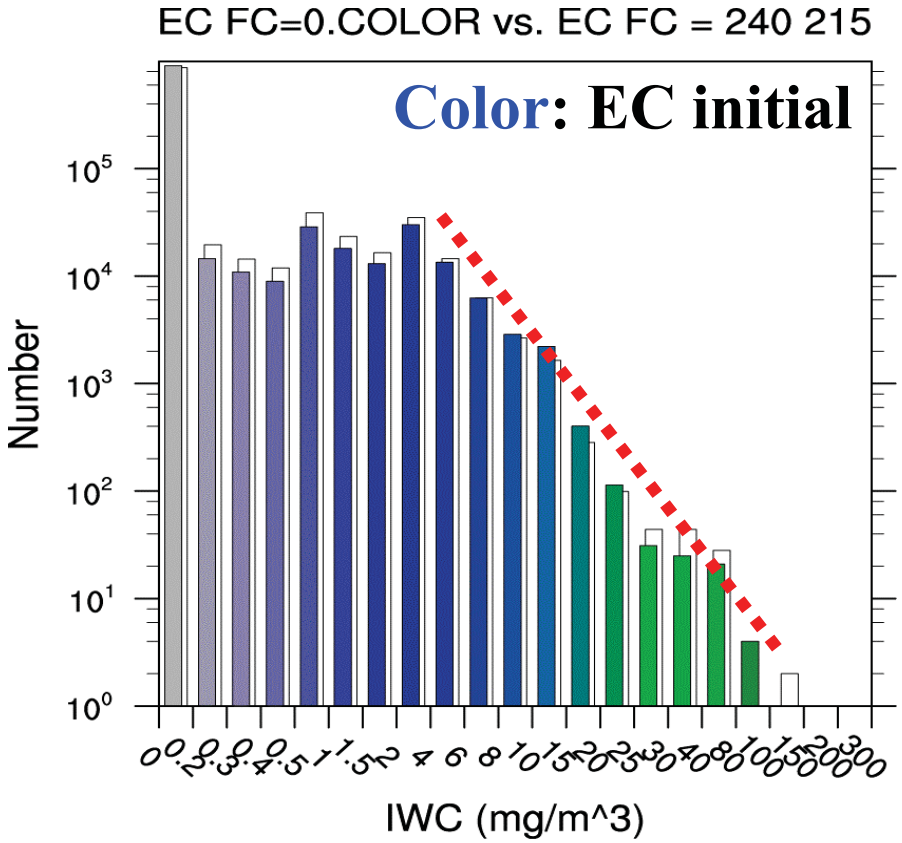
As lead time increases, the model's systematic biases develop and system evolves away from the initial conditions which were constrained by observations.

Annual IWC PDF: ECMWF vs. MLS

ECMWF Sampled along MLS tracks

215 hPa



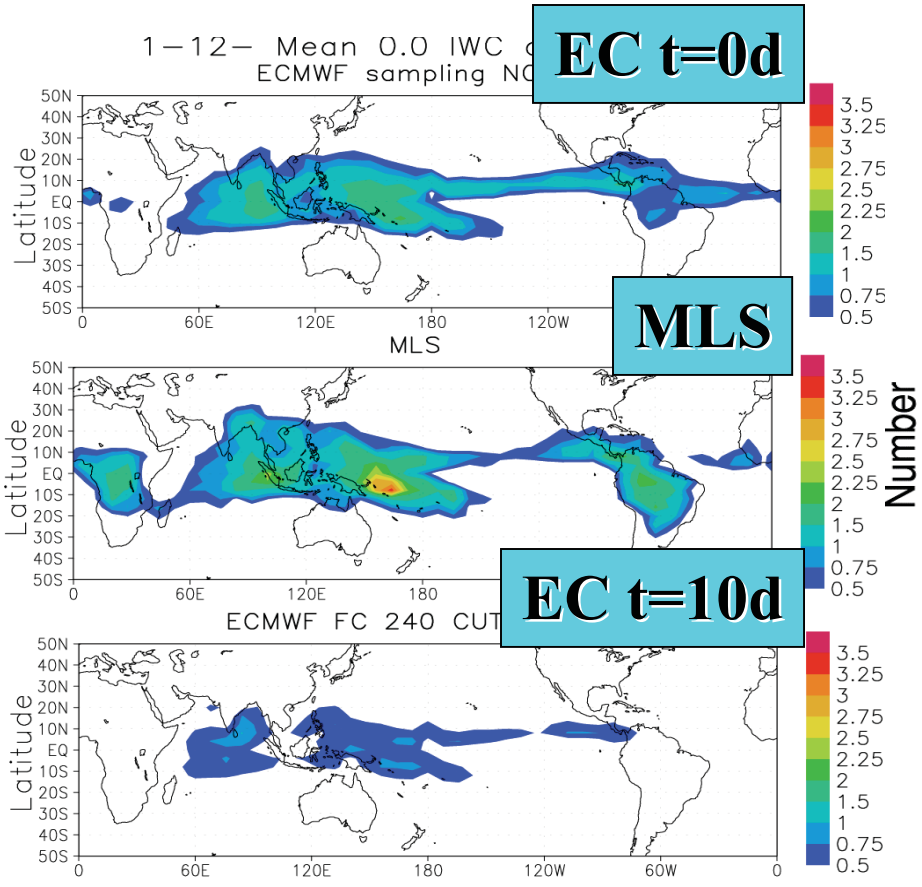


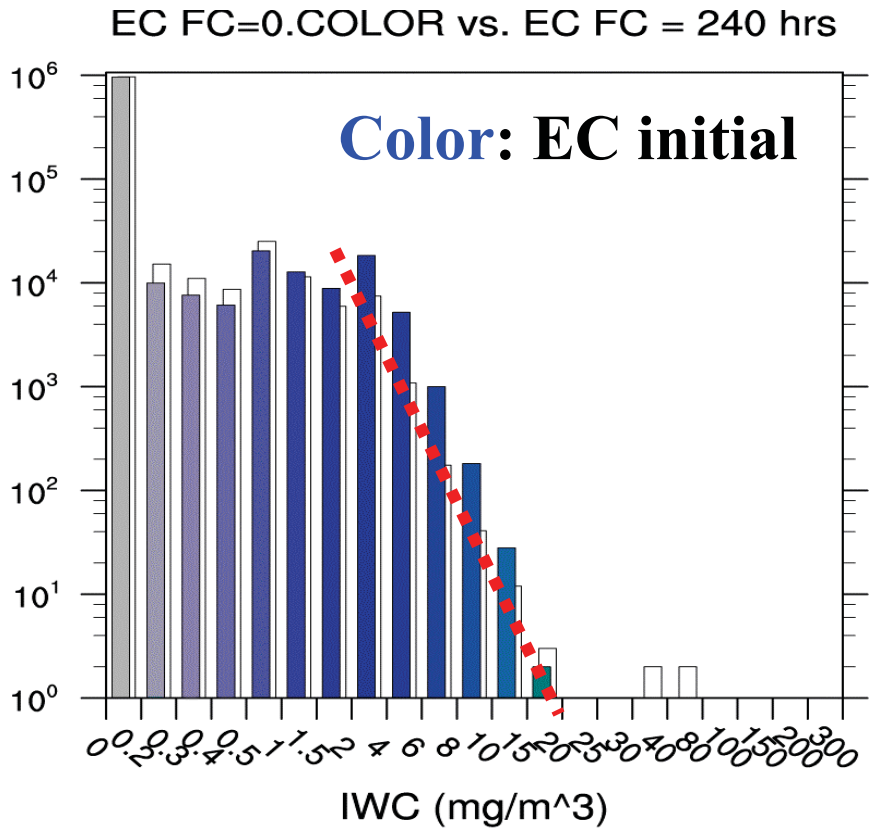
- The difference is small between the reanalysis and 10-day forecast at levels 215 hPa and lower (not shown).
- Both are smaller than MLS IWC.

Annual IWC PDF: ECMWF vs. MLS

ECMWF Sampled along MLS tracks

147 hPa

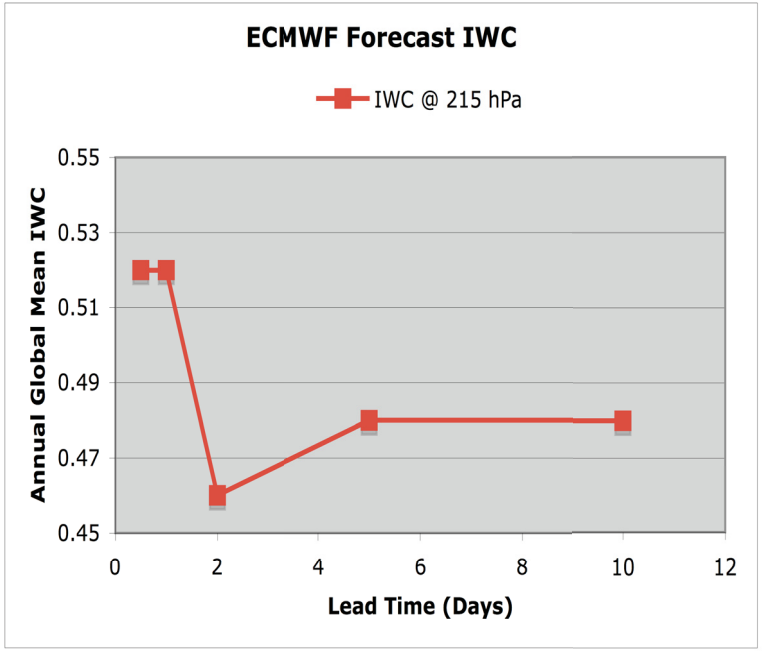


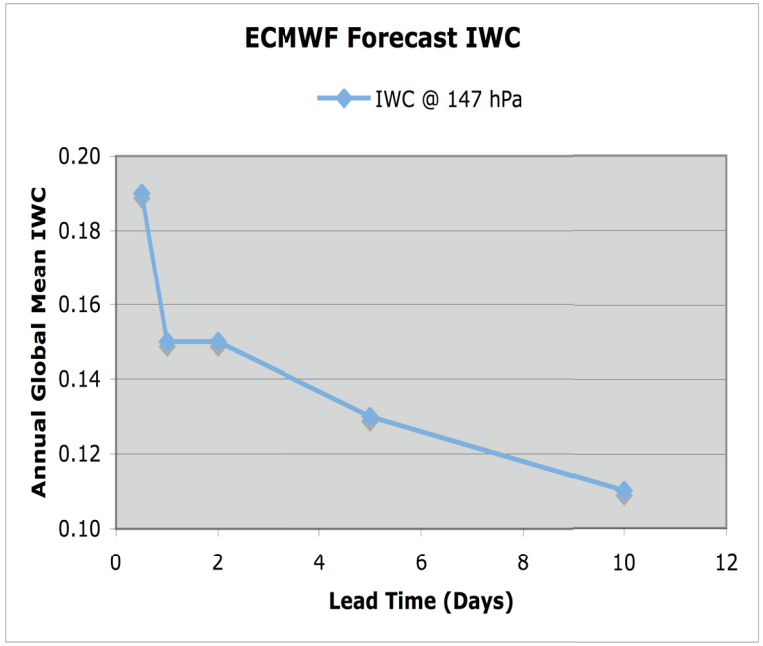


- 10-day forecast bias is large @ 147 hPa and above (not shown)
  - Too weak large-scale upward motion; investigating….

Annual IWC PDF: ECMWF vs. MLS

ECMWF Sampled along MLS tracks

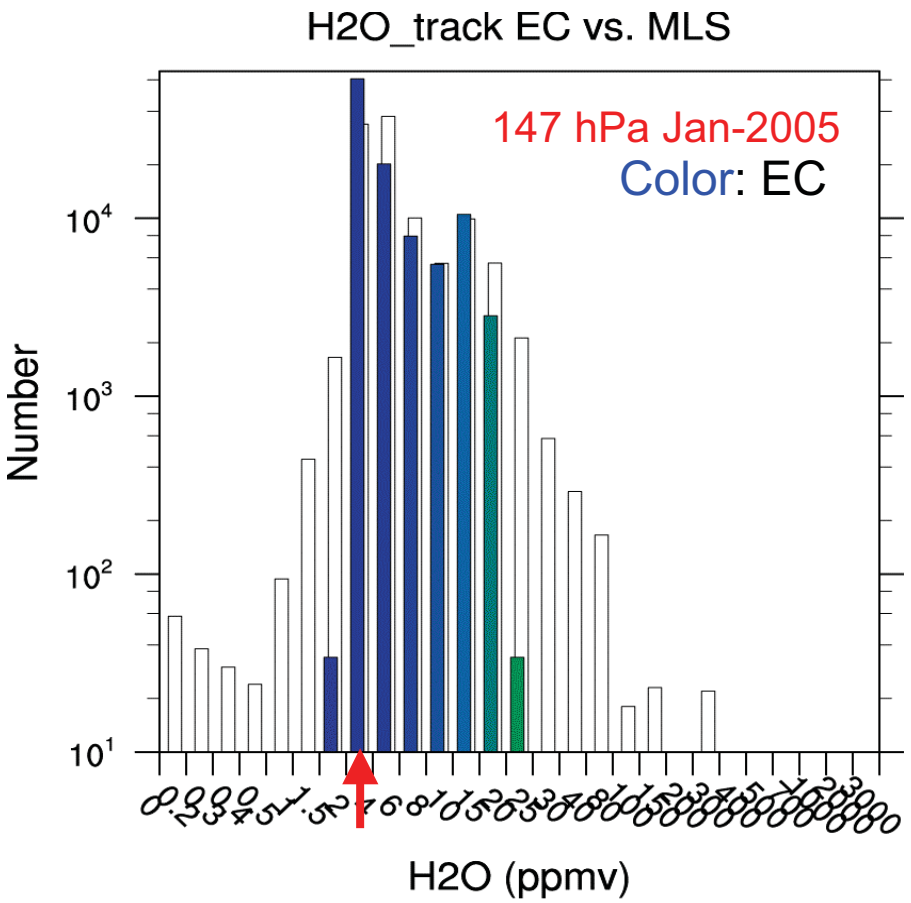


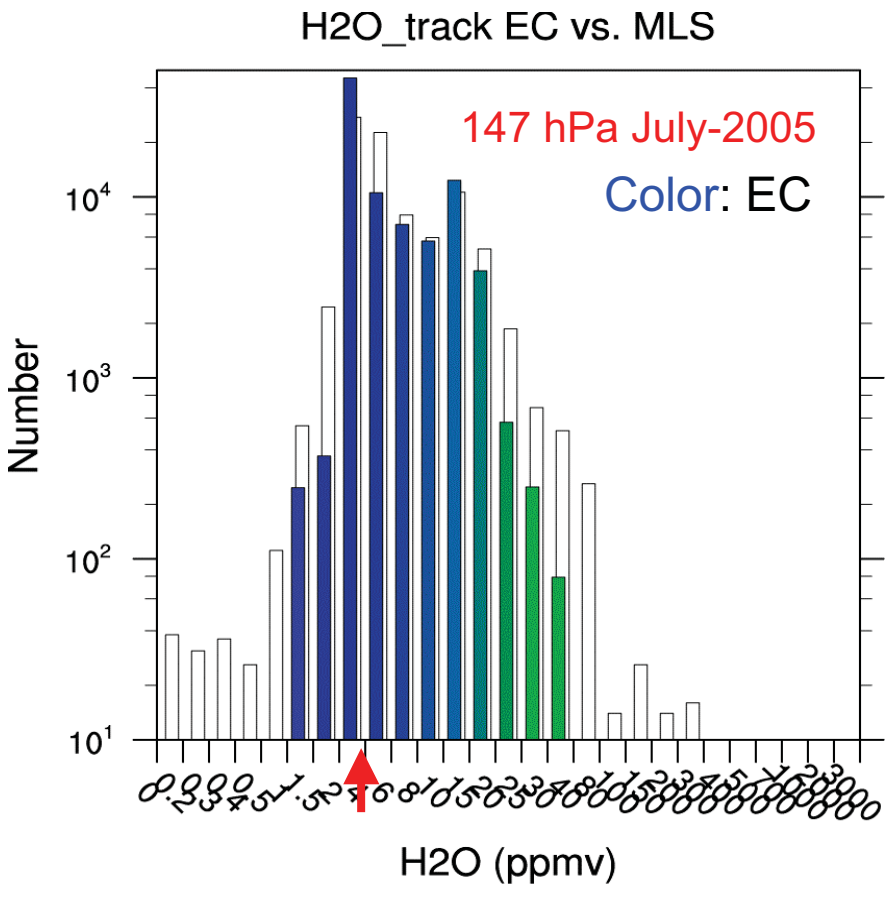


Some systematic bias development, particularly at highest levels.

Annual H2O PDF: ECMWF vs. MLS

ECMWF Sampled along MLS tracks





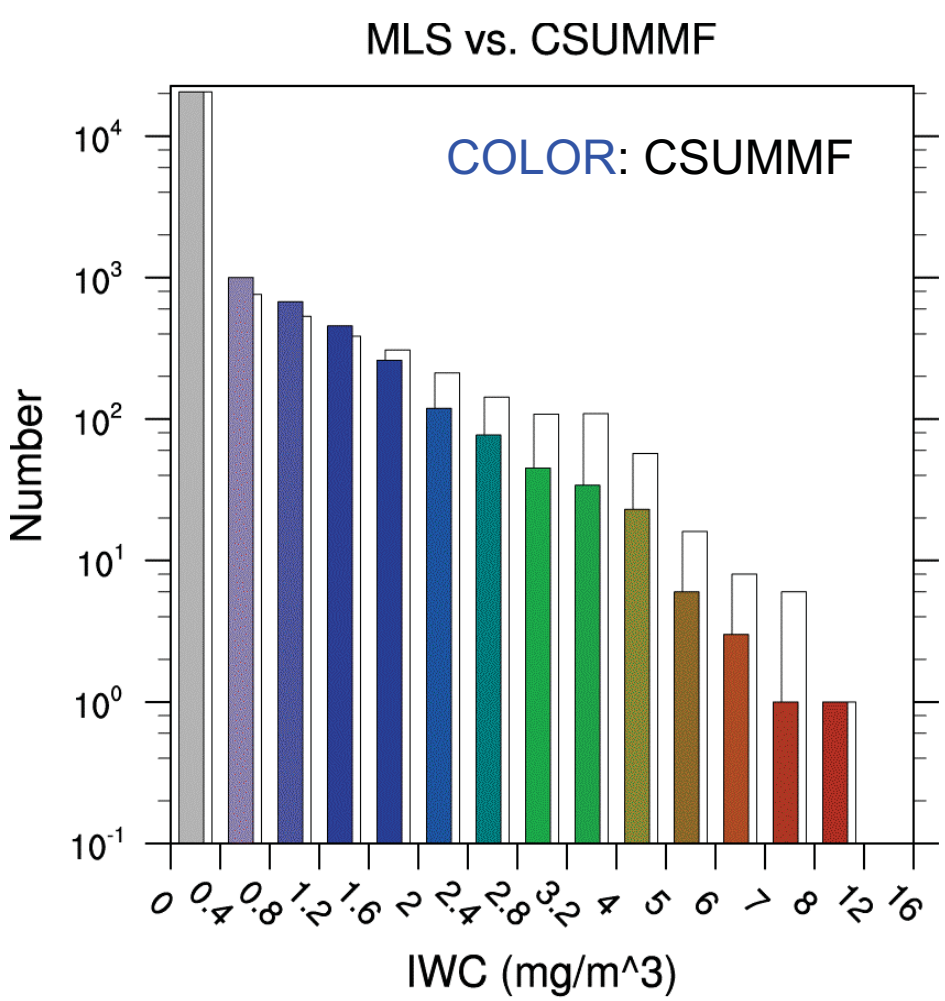
- The ECMWF might have a lower limit set for example, 1.89e-06 (kg/kg) ~ 3.255 (ppmv). We are looking at this.
- How does MLS H2O sensitivity influence the above distribution/ comparison?

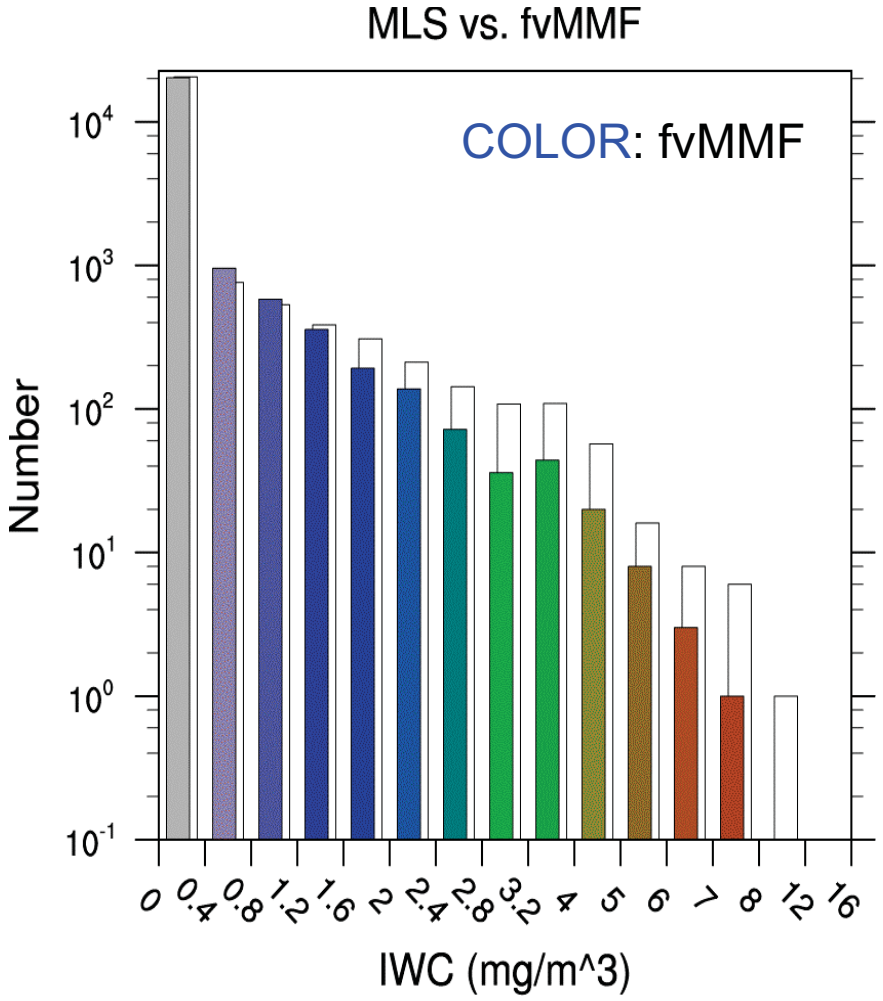
MMF Simulations

Convective/cloud parameterizations replaced by a 2-D cloud model at each GCM grid point.
"Experimental/State-of-the-art"

No sampling/cutoffs applied: working with monthly data from arbitrary years.

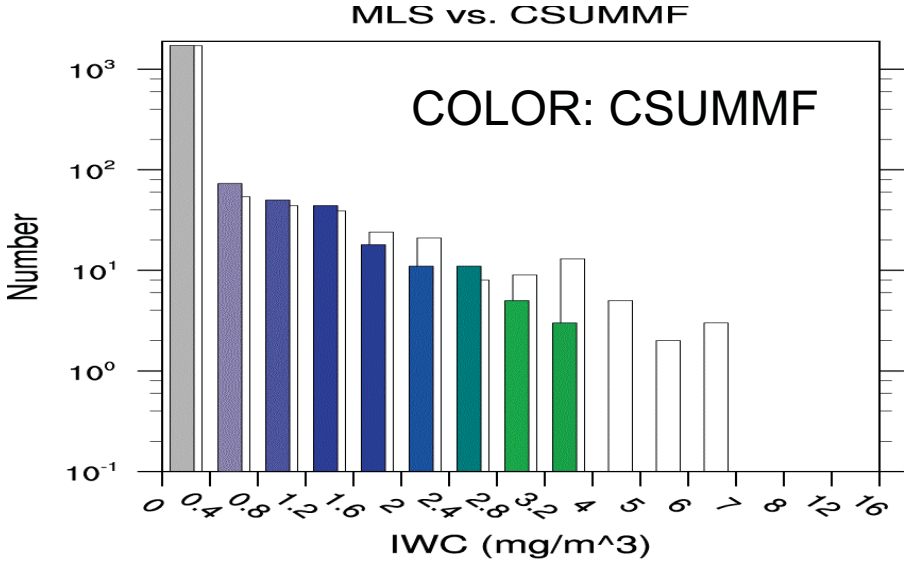
IWC 147 hPa
Jan~Dec (12 months)



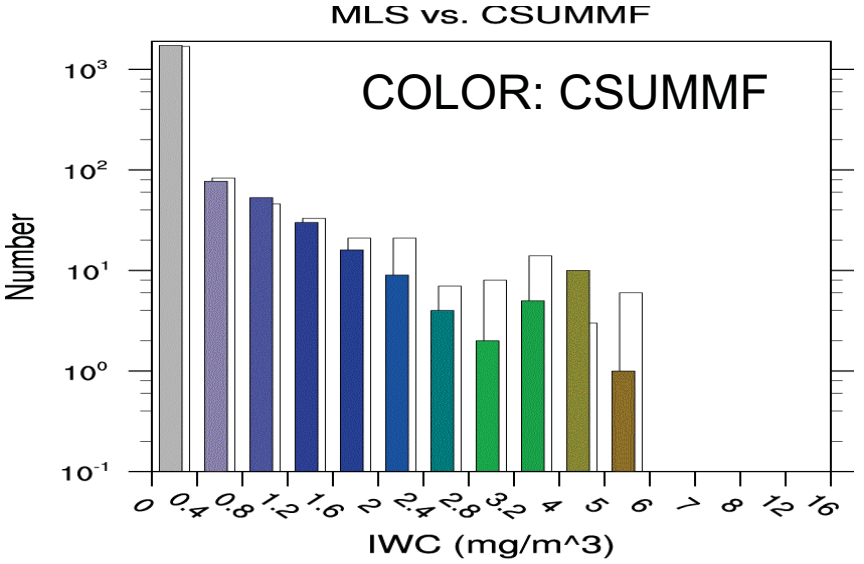


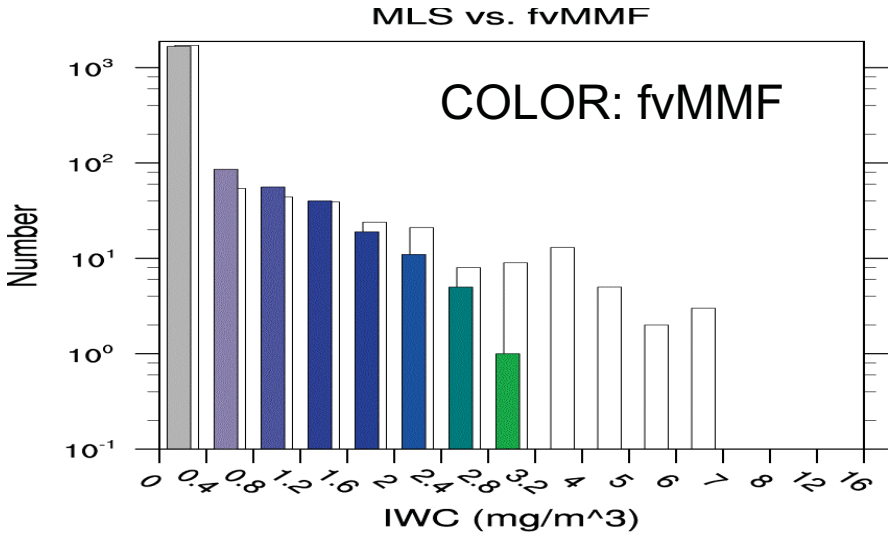
MMF IWC 147 hPa

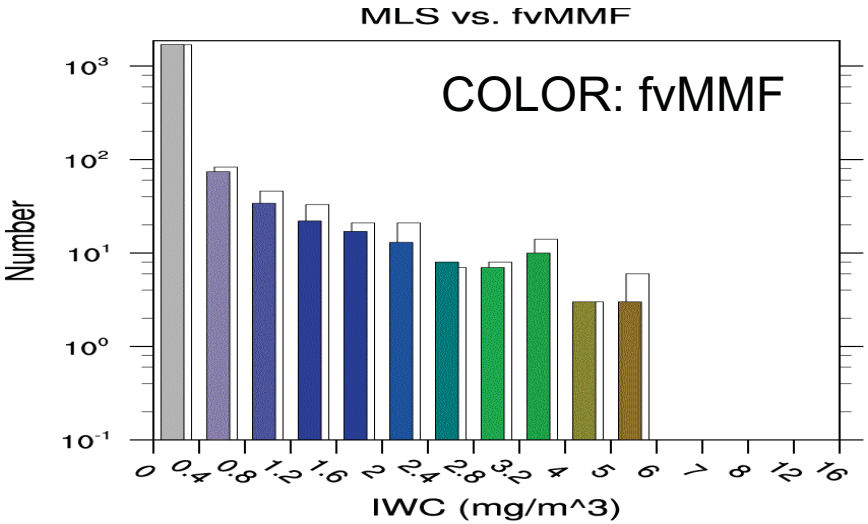
JAN



JULY







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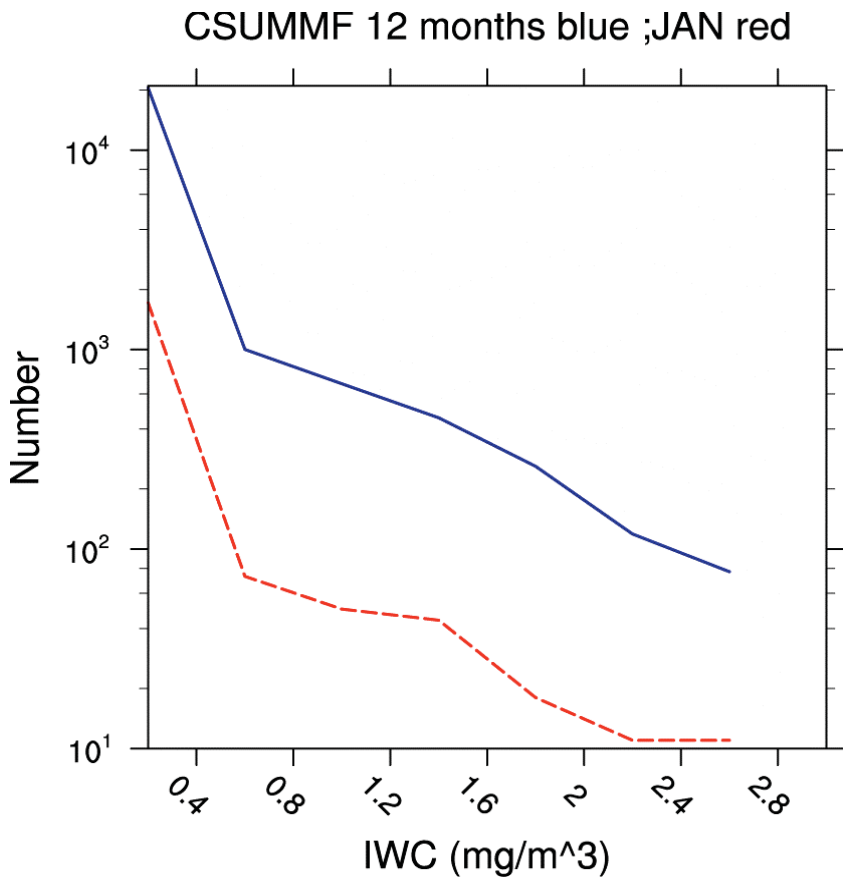
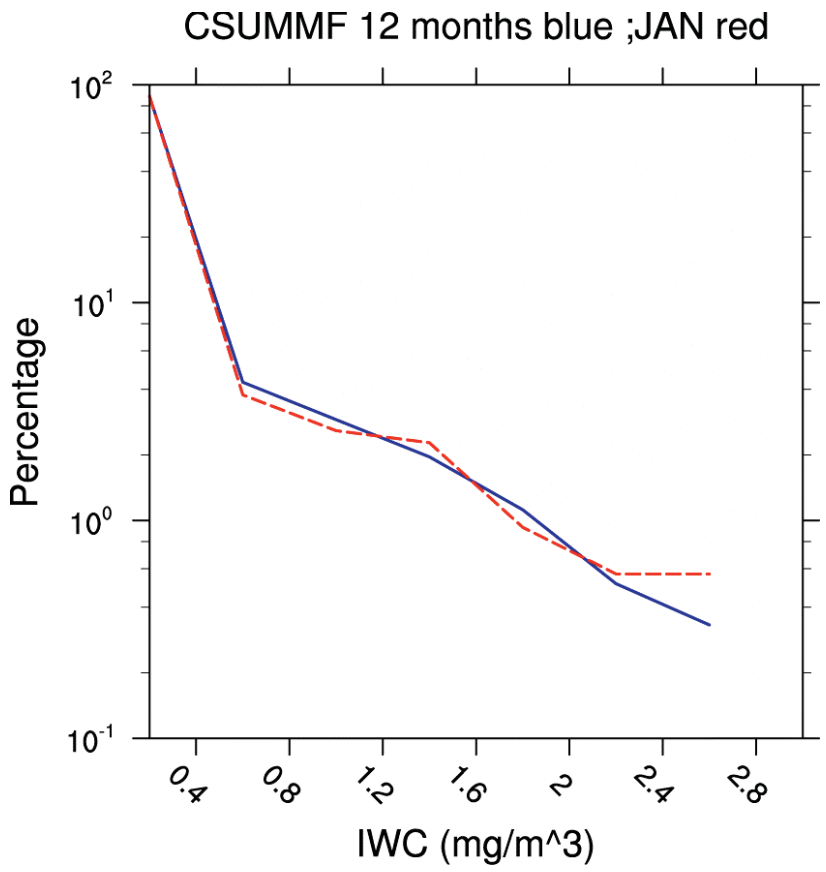
CSUMMF IWC 147 hPa





12 month total: Blue

Single month: Red

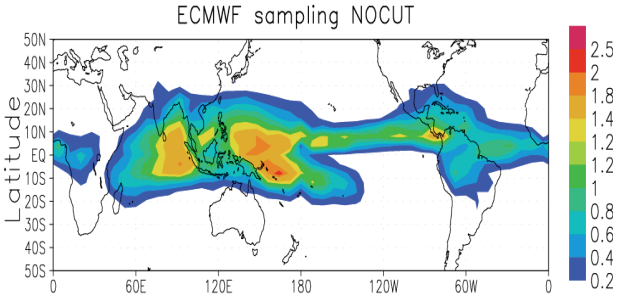
Indicates we can get a good approximation of the model's PDF from a short period of data. Would like to use instantaneous rather than averaged values.

CSUMMF IWC (15 years mean) @147 hPa

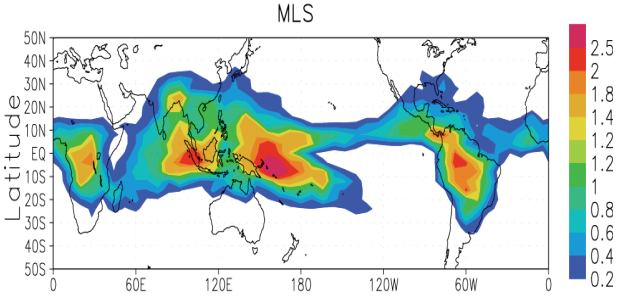
ANNUAL

1-12- Mean 0.0 IWC at 147 hPa

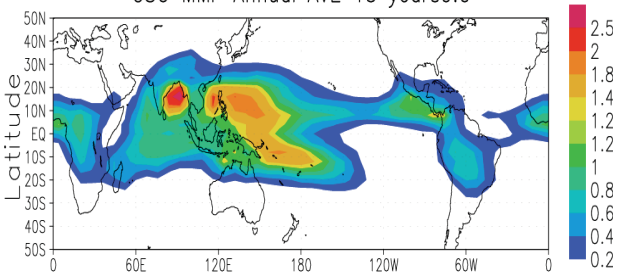
ECMWF



MLS



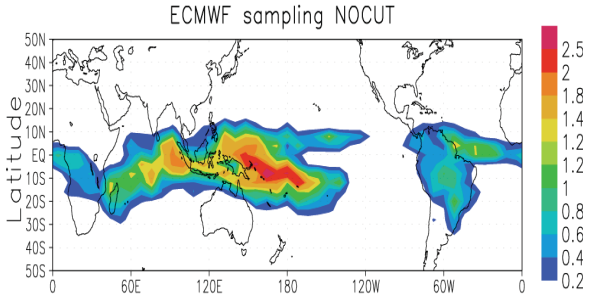
CSUMMF



JAN

6-6- Mean 0.0 IWC at 147 hPa

ECMWF



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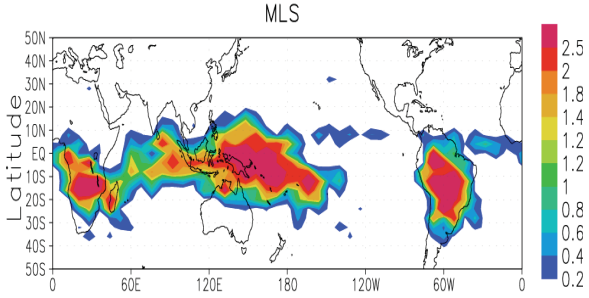

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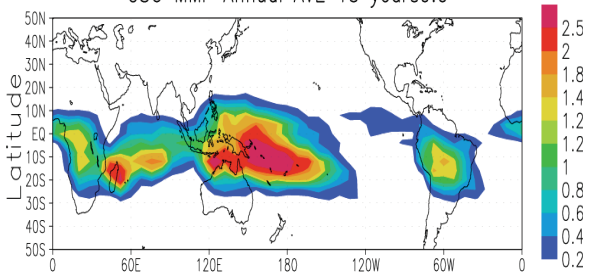
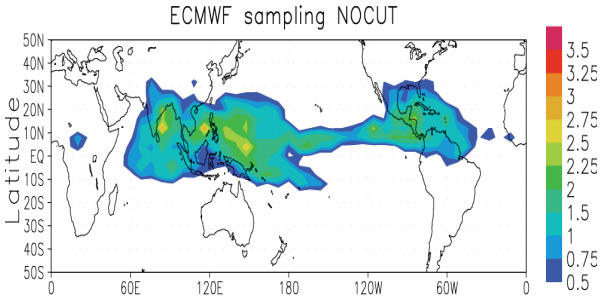


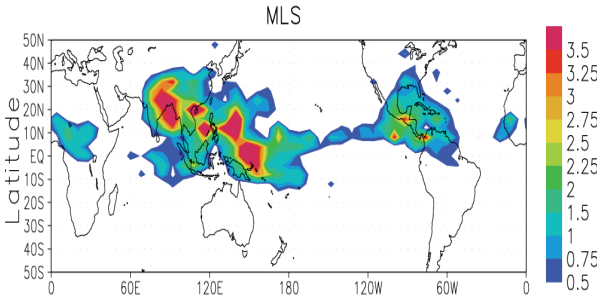
JUL

12-12- Mean 0.0 IWC at 147 hPa

ECMWF



MLS



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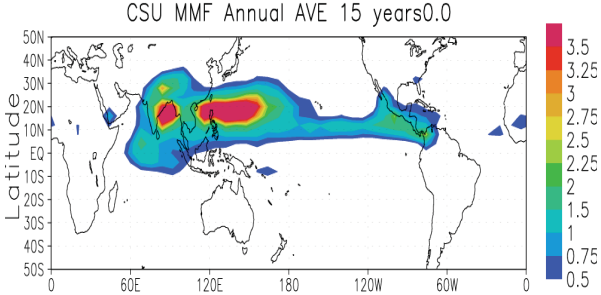

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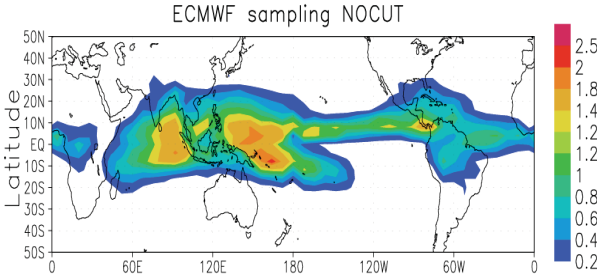
fvMMF IWC (1998 1999 mean) @147 hPa

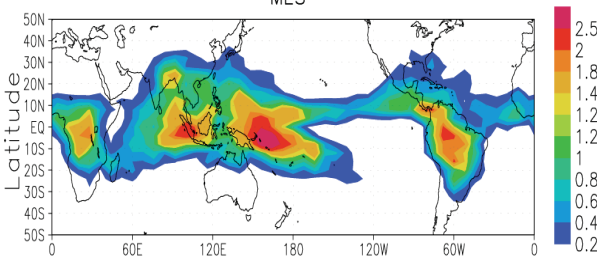
ANNUAL

1–12– Mean 0.0 IWC at 147 hPa

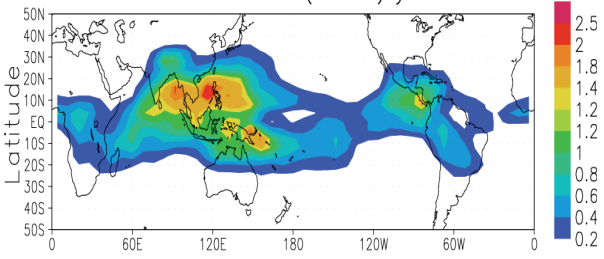
ECMWF



MLS



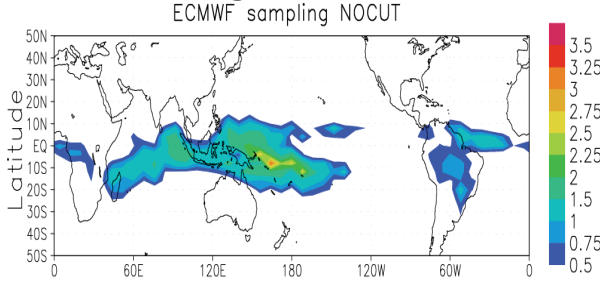
fvMMF



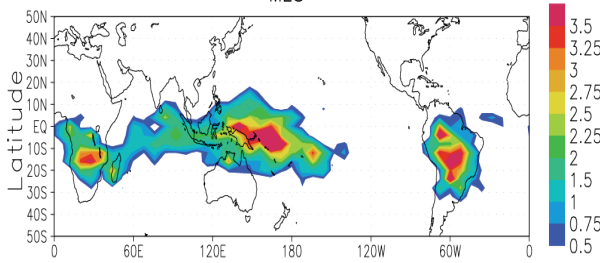
JAN

6–6– Mean 0.0 IWC at 147 hPa

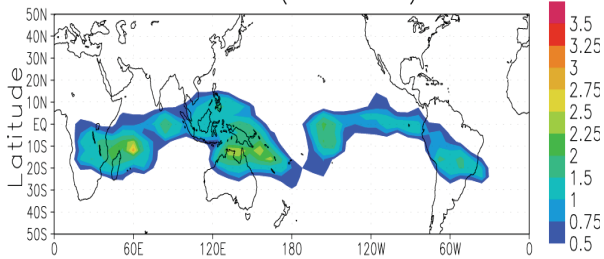
ECMWF



MLS



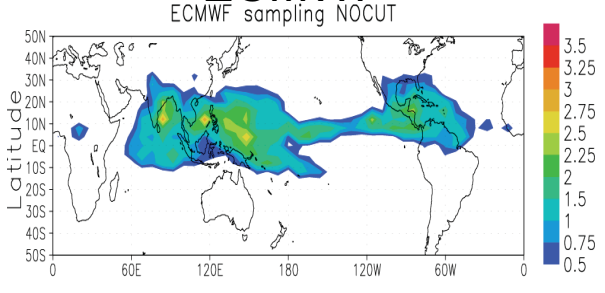
fvMMF



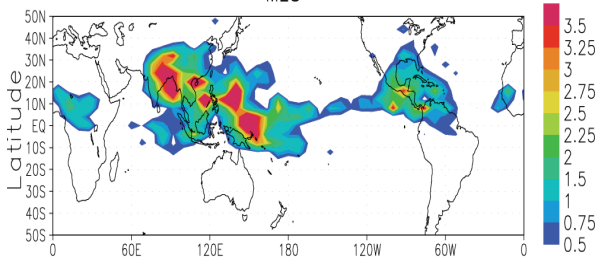
JUL

12–12– Mean 0.0 IWC at 147 hPa

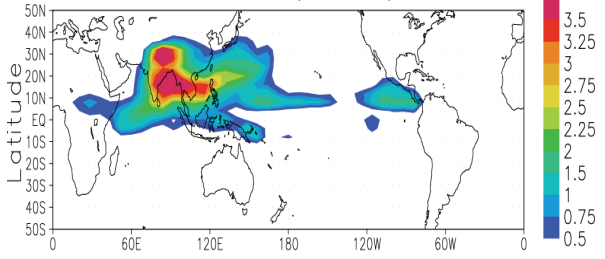
ECMWF



MLS



fvMMF



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Summary to Date

- **MLS vs. "fully-sampled" ECWMF Analysis**
  - **MLS IWC overall tends to be higher relative to ECMWF after considering MLS track sampling and sensitivity (cutoff application).**
  - **Disagreement tends to be accentuated over Indian and Western Pacific Oceans and over tropical landmasses.**
- **MLS vs. ECMWF Forecast**
  - **Large disagreement occur at upper level at 147 hPa but small at lower levels at 215 and 316 hPa suggesting the need to investigate the strength of model large-scale circulation and physics associated with the IWC formation.**

Near-Term and Future Work

- Present MMF/ECMWF Comparisons at AGU/Baltimore Session on MMF / Cloud Resolving Modeling, GMAO/GSFC & at the WPac/Bejing/AGU in Tao's Cloud-Radiation Session.
- Write-up Results on ECMWF/MLS Comparisons for GRL.
- Continue with MLS vs ECMWF Water Vapor & Temperature comparisons - will seek more interaction with other MLS colleagues.
- Investigate the Development of Biases in ECMWF Forecasts - i.e. in the actual model.
- Work with GMAO-5 development team regarding their cloud microphysics performance.
- Integrate CloudSat into IWC Analyses.